Reserves Accumulation in African Countries: Sources, Motivations, and Effects[*]

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Abstract

African countries have accumulated substantial foreign currency reserves in recent years, mostly from higher commodity exports as well as aid flows. In the context of macroeconomic stabilization, which remains at the forefront of national economic policymaking and aid conditionality, African countries are induced to hold reserves to allow monetary authorities to intervene in markets to influence the exchange rate and inflation. Adequate reserves also allow the country to borrow from abroad and to hedge against instability and uncertainty of external capital flows. However, reserve accumulation can have high economic and social costs, including a high opportunity cost emanating from low returns on reserve assets, losses due to reserve currency depreciation, and forgone gains from investment and social expenditure that could be financed by these reserves. Therefore, African countries need to have a better understanding of the determinants and economic costs of reserve accumulation and to design optimal reserve management strategies to minimize these costs. This study uses panel data from 21 African countries to examine the causes and economic implications of reserve accumulation with a focus on the impact on the exchange rate, inflation, and public and private investment. While the level of reserves remains adequate on average, some countries have accumulated excessive reserves especially in recent years. Empirical analysis shows that the recent reserve accumulation cannot be justified by portfolio choice motives (in terms of returns to assets) or stabilization objectives. At the same time it has resulted in exchange rate appreciation while it has yielded little benefits in terms of public and private investment. The evidence suggests that African countries, especially those endowed in natural resources, need to adopt a more pro-growth approach to reserve management.

1. Introduction

The buildup of reserves in Africa and emerging economies has accelerated over the last decade with the bulk of the increase occurring in oil-exporting countries. The accumulation of reserves has occurred at a time of generally stable or slightly appreciating exchange rates, particularly against the US dollar. Countries generally maintain reserves in order to effectively manage their exchange rate and to reduce adjustment costs associated with fluctuations in international payments. Accordingly, demand for international reserves increases with global trade. Empirical research shows that both the variance and level of trade (current account and openness to trade or the propensity to import) are important determinants of demand for reserves (see Mendoza 2004). In practice, however, most countries follow the "rules of thumb" in determining the optimal level of reserves, including maintaining reserves equivalent to at least three months of imports (Mendoza 2004).

However, the recent accumulation of reserves in developing countries has been largely interpreted as a form of self-insurance precipitated by the high level of global economic and financial instability and the absence of an adequate international system for crisis management. The 1997 East Asian financial crisis is a good example in this regard (Stiglitz 2006). Moreover, many countries see reserve accumulation not only as a means for effective exchange rate management, but also as a tool for maintaining low exchange rates in order to promote trade and international competitiveness. This motive for holding reserves is referred to as the mercantilist motive (Aizenman and Lee 2005).

Maintaining adequate reserves can also boost investors' confidence and hence enhance investment and growth. This can be more clearly seen in the case of Asian countries that recorded the highest rate of increase in international reserves following the 1997 financial crisis coupled with high growth in external trade and output. A recent study shows that reserve buildup in emerging Asia between 1997 and 2002 was large both in absolute terms and relative to imports and short-term external debt (IMF 2003). The study also points out that the reserve buildup in emerging Asia has been similar across exchange rate regimes, including countries with limited exchange rate flexibility as well as countries with managed floating exchange rates. More importantly the reserve buildup in 2002 has been in excess of that warranted by the economic fundamentals of the region. Increases in international reserves in Latin America have been largely in line with rising in imports and commercial transactions in general and was only partially driven by demand for insurance against financial shocks (Eichengreen 2006).

The import cover notion of reserves appeared inadequate with high capital mobility and costly financial crisis caused by sudden reversals in capital flows during the last two decades. Therefore, developing countries need to hold reserves at least equal to their short-term foreign currency debt. Evidence suggests that higher reserves reduce both the likelihood of a crisis and the depth of a crisis, should one occur (IMF 2003). IMF (2003) suggests that "a ratio of reserves to short-term external debt above one marks an important reduction in crisis vulnerability, as long as the current account is not out of line

and the exchange rate is not misaligned". At the global level, there is still a need for a more effective global insurance framework or an international monetary system that can help prevent financial shocks or mitigate their costs.

For Africa, recent commodity price hikes have allowed reserves accumulation among exporters, while draining reserves among importers. Meanwhile, macroeconomic stabilization remains at the forefront of national economic policymaking and aid conditionality in Africa (see Lapavitsas 2007; Mckinley 2007; Weeks 2007). This induces countries to hold reserves to allow monetary authorities to intervene in markets to influence the exchange rate and inflation. Adequate reserves may also allow African countries to borrow abroad, attract foreign capital and promote domestic private investment as a result of strengthened external position and reduced vulnerability to external shocks.

These benefits should be carefully weighed against potentially high economic and social costs. The costs of maintaining reserves comprise the opportunity cost of foregone domestic consumption and investment as well as financial costs and the strain on monetary policy arising from efforts to sterilize the effects of excessive monetary expansion through higher domestic interest rates.[1] This can increase fiscal pressure (control of government spending and deficits) and make reserve accumulation inconsistent with fiscal policy objectives. In addition, reserve buildup can pose challenges to the macroeconomic policy framework. It is impossible for government to reconcile policy objectives vis-à-vis exchange rate stability through a fixed exchange rate, monetary independence, and free capital mobility. While it is possible to combine selective capital controls with occasional interventions in the exchange rate market, still inconsistencies may arise. For example if the economy is overheating, accumulating reserves and keeping domestic currency from appreciating might be inconsistent with a tight monetary policy. Higher domestic interest rates resulting from sterilization may also be inconsistent with a tight fiscal policy (as higher interest payments put pressure on the fiscal balance), leading to greater inflation, and exchange rate and output volatility (UN-DESA 2007).

More importantly, reserve accumulation in developing countries is akin to buildup of deficits in reserve asset countries, especially the US. Thus adjustments in the US might have important costs for the reset of the world, especially reserve-accumulating countries.[2] The question of how to manage large foreign exchange reserves effectively

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[1] Developing countries earn 1 to 2 per cent real return on their $3 trillion reserves. They could invest these reserves locally with returns of 10 to 15 per cent. Assuming a difference of 10 per cent between domestic and foreign returns, the opportunity cost of holding reserves is quite high, well in excess of $300 billion per year – more than 2 per cent of GDP (Stiglitz 2006). According to Stiglitz (2006), the total opportunity cost of reserves is roughly equal to the amount of funds needed by developing countries to finance necessary investments to meet the MDGs.

[2] For example, the recent depreciation of the dollar relative to the Euro meant a more than 30 per cent opportunity cost to dollar-dominated asset holders (Stiglitz 2006). This

also arises because available reserve assets may not provide an optimal risk-return mix. In the long run there is a need for an alternative reserve system. Furthermore, governments need to stimulate domestic demand along with growth in exports and real GDP, strengthen domestic financial markets and integrate them into the global market in order to reduce precautionary demand for reserves.

To effectively manage foreign exchange reserves, policy makers need to understand the major determinants of reserves in a globalized world. This is essential in determining the optimal reserves level that provides them with necessary security at minimum cost. In this context, some slowdown in the rate of reserve accumulation is likely to be justifiable for commodity-rich African countries that need to finance high-yield domestic investments instead of locking up the reserves in low-yield foreign assets. Designing a successful reserve management system for African countries requires important institutional and policy reforms at the national and regional levels. These include policies to enhance domestic demand and intra-African trade, improved exchange rate management and above all a new regional or global reserve system.

This paper uses panel data for 21 African countries for the period 1979-2005[3] to examine the motivation and sources of reserves accumulation in African countries and its economic implications in terms of the exchange rate, inflation, and public as well as private investment (see table A1 for list of countries and selected economic indicators). In contrast to the case of emerging economies, the results confirm that to some extent the reserve buildup contributes to appreciation of the national currency rather than undervaluation. The evidence further indicates that countries have reaped little gains from the trade-driven reserve accumulation in terms of public and private investment. On the basis of the empirical analysis, the paper assesses policy options at the national, regional and global levels for African countries to effectively manage reserves so as to maximize the gains from higher foreign exchange receipts while minimizing their adverse effects on the economy.

The next section examines the trend of reserve accumulation in Africa in absolute terms and relative to imports, output and money supply. The section also identifies the main sources of reserves build up. Section 3 presents the analytical framework of the study by specifying a reserve demand equation and econometric models for assessing the economic consequences of reserve accumulation on the exchange rate, inflation and domestic investment. Econometric estimation and discussion of results are presented in Section 4. Section 5 concludes with policy recommendations.

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highlights some of the weaknesses of the global reserves system and indicates the need for central banks to diversify reserves.

[3] The choice of this period was dictated by data availability and the desire to maximize the number of observations.

2. Reserves buildup in Africa: trends and specific motivation

2.1 Sources of reserves: Key balance of payments (BoP) identities

Evidence indicates that the origins of reserve accumulation differ by country. In Latin America, a persistent current account deficit was balanced by a current account surplus for most of the last decade. Larger capital account surpluses helped some countries such as Brazil and Venezuela to accumulate reserves. Since the 1997 crisis, East Asia has run capital account deficits and continuous current account surpluses, except for China that maintained twin surpluses (UN-DESA 2007).

The first task in our study involves a careful examination of the sources of reserves accumulation and factors/determinants of reserves accumulation in African countries. This exercise allows us to investigate the extent to which reserve accumulation is the outcome of explicit decisions by the monetary authorities, rather than a result of exogenous events such as commodity prices, debt forgiveness, or external factors such as foreign investors' appetite for domestic assets.

The analysis will be based on the following standard Balance of Payments (BoP) identities:

$$CA + KFA + \Delta RES = 0 \tag{1}$$
Or:
$$CA + KFA = -\Delta RES \tag{2}$$

Where CA is the current account balance, KFA the capital and financial account balance, and ΔRES change in reserves. Net errors and omissions are generally added on the left-hand side to account for statistical discrepancies.

The current account balance may also be defined as:

$$CA = GSA + IA + TA \tag{3}$$

Where GSA is the balance on goods and services, IA the balance on income, and TA the balance on transfers.

For African countries, most of the movement is in the GSA (imports and exports). But TA also has gained increasing importance due to, among other things, worker remittances. The capital and financial account balance is given by:

$$KFA = KA + FA \tag{4}$$

Where KA is the capital account balance, which includes debt forgiveness; FA the financial account, which is equal to the sum of FDI plus portfolio investment and other investments.

Reserves include gold, SDRs, the reserve position in the IMF, and foreign exchange. The foreign exchange component of reserves includes currency (mainly US dollars) plus deposits with monetary authorities and banks plus securities (US/foreign government securities, equity, bonds and notes, money market instruments and derivatives).

2.2 Trends and motivation for reserve buildup in Africa

Accumulation of foreign exchange reserves by African countries may best be understood in the context of reserves behavior in developing regions in general. Global official foreign exchange reserves rose from US$1.2 trillion in January 1995 to US$5.04 trillion in December 2006, and the share of developing countries in world reserves increased from 50 to 72 per cent over the same period. This large share needs explanation especially in view of the fact that developing countries accounted for only 41 per cent of world trade in 2005. The question here is why developing countries need to accumulate relatively more reserves than developed countries? And how does reserve accumulation relate to foreign trade and output growth?

The regional breakdown of reserves buildup suggests a positive correlation between reserves buildup on the one hand and trade and output on the other. On average the East Asia and Pacific region has accumulated more foreign exchange reserves than other developing regions over the last decade (figure 1).

However, in addition to relatively high trade-driven growth, the East Asia and Pacific region witnessed the severest financial crisis in the last two decades. In this context analysts identify three factors, beside high oil prices, for the buildup of reserves in developing countries (ECB 2006). The first factor is the need for insurance against future crisis precipitated by financial crisis in the 1990s and early 2000s. The second factor relates to the strong export-led growth in Asia following large exchange rate depreciation in the region as a result of the financial crisis. Finally certain features of the domestic financial markets of emerging economies in general and the Asian markets in particular have stimulated the unprecedented accumulation of reserves. These include weak financial intermediation between domestic savers and investors and inefficient hedging markets; the tendency towards dollarization of international assets; and excess domestic savings over investment.

The accumulation of official reserves as an outcome as well as a means of integration into global financial market is a common factor behind the recent reserve buildup in emerging markets (ECB 2006). Emerging economies, especially in Asia, have the need to accumulate reserves to protect their economies against financial market fluctuations because while they are major players in international trade they still lag behind in terms of financial market development.

However, the buildup of reserves creates new risks. As the bulk of foreign exchange reserves is held in US assets and used to finance current account deficits in developed countries, reserve holding countries become susceptible to risks and costs emanating from adjustments in reserve currency countries. These risks and costs include inflationary

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pressures, over-investment, asset bubbles, complications in the management of monetary policy, potentially sizable capital losses on monetary authorities' balance sheets, sterilization costs, segmentation of the public debt market and misallocation of domestic banks' lending (ECB 2006).

To mitigate these risks and costs, developing countries must exercise active reserve management and diversification. This is a major challenge in Africa especially for resource-rich countries. Ultimately these countries need policies to slowdown the need for reserves accumulation given the high opportunity costs in terms of returns. These policies may include adoption of a more expansionary fiscal policy emphasizing productive public investments, macroeconomic measures to enhance domestic demand or regional demand, domestic and regional financial market development including bond market development, increased exchange rate flexibility together with money market reforms, and regional economic and monetary cooperation to reduce the need for reserve accumulation by individual countries (ECB 2006:3).

The trend of foreign currency reserves relative to imports and external short-term debt clearly illustrates the strong influence of the recent factors discussed above in relation to reserves accumulation in Africa. In all the developing regions, reserves have generally increased as a ratio of imports of goods and services during the last ten years (Figure 2). This ratio is an indicator of the country's current account vulnerability and it is generally held that a ratio of 3 to 4 months is considered adequate for the country to finance its imports. On average official reserves in Africa rose from the equivalent of about two months of imports in 1990 to about 5 months in 2004. This suggests that on average reserve holdings of African countries are just adequate.

But the average reserve-import ratio masks huge variations across African countries. For example, Algeria had total reserves, excluding gold, of $66.1 billion (the equivalent of 32 months of imports) in 2006 compared to $56.3 billion (34.5 months of imports) in 2005, while Morocco had $17.7 billion (10.1 months of imports) in 2006 and $16.2 billion (10.3 months of imports) in 2005 (UNECA 2007). For Chad and Eritrea, foreign exchange reserves represented only two months of imports in 2006. For the 40 African countries with available data, reserves represented 10 months of imports in 2006. The respective import cover for oil-exporting and oil-importing countries was 15 months and 5 months. This raises the question of why some African countries are accumulating excess reserves in recent years and what policies they should adopt to avoid this in the future.

The literature suggests that a ratio of reserve to short-term external debt of more than one indicates adequate capacity of the country to service its external liabilities and face unexpected financial risk in case of deteriorating external financial conditions. Conversely a ratio of less than one indicates vulnerability to capital account risks (IMF 2003). Figure 3 shows that since around 2004 this ratio has risen above 2 for African countries. By 2005, on average, African reserves as a ratio of short-term external debt exceeded that of all other developing regions with the exception of South Asia. The

higher ratios for relatively poorer developing regions may reflect greater desire for self-insurance against external shocks.

The above ratios underline reserve adequacy in African countries in general, but they cannot explain the recent strong upward trend of reserves among resource-rich countries in particular. Indeed, figure 4 shows that oil-exporting African countries have accounted for about 75 per cent of total African reserves in 2005-2006. Tables A2 to A5 in the appendix present the statistics on reserve accumulation and composition distinguishing between oil-rich and non-oil-rich countries. Oil-exporting countries are also the main recipients of private capital flows, especially FDI. Noting that none of the top 10 countries in terms of reserve-GDP ratio is a high aid recipient county, it is clear that commodity revenue, especially oil revenue, and related private capital inflows are the key source of reserve buildup in Africa.

Reserve accumulation could also be the result of as well as an instrument of attracting aid flows when donors perceive reserves as a signal of sound macroeconomic management. Both private and official capita flows to Africa increased especially since 2002 but at a rate far less than the rate of reserve growth (Figure 5). In fact official flows have almost leveled off in the last 3 years. It is worth noting that while accumulation of reserves by resource-rich African countries often coincides with overvalued exchange rates that can adversely affect growth in non-oil exports.

2.3 Sources and composition of African foreign exchange reserves

The figures in table 1 show that the 21 African countries for which detailed data exist have recorded very high rates of growth of foreign exchange reserves since the turn of this century. Reserve flow is the sum of the current account balance and the capital and financial account balance. This sample of African countries as a group recorded current account surpluses for most of the period under review, mainly because of high current account surplus in resource-rich countries and net transfers; the income balance has always been in deficit.

Regarding the capital and financial account balance, while the capital account switched between surplus and deficit over the years, the financial account balance has shown net financial inflows to Africa since 1990. These financial flows, including ODA and increasing remittances by African nationals working abroad, contributed to the high rate of reserves accumulation during this period. Overall sustained current and capital account surpluses in mainly resource-rich countries are behind the high growth in reserves in Africa. However, exchange rate policies that favor overvalued currencies are perhaps the root cause of the general trend in the continent. Large reserve holding countries in Africa in particular need to carefully assess the risks relating to the security of their reserves as well as the opportunity costs in terms of investment and growth. In fact maintaining large stocks of reserve and overvalued exchange rates at a time of low trade capacity encourages imports of consumer goods and can retard investment, economic diversification and growth.

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The composition of African reserves highlights high exposure of reserve holders to global financial risks. Over the last few years, more than 95 per cent of African non-gold reserves were held in foreign exchanges including currency (mainly the US dollar) plus deposits with monetary authorities and banks and securities (US/foreign government securities, equity, bonds and notes, money markets, derivatives). Thus the value of African reserves can change with fluctuations in the reserve currency (especially the US dollar) or wider global financial market fluctuations. The safest reserve asset, treasury bills, pays the lowest rates of return. Again this makes efficient reserve management a top priority for reserve holders.

3. Empirical analysis

3.1 The demand for reserves

After identifying the sources of reserve accumulation from balance of payments data in the previous section, the first objective of this study is to use econometric models to examine the determinants of the demand for reserves.

The literature suggests that reserves are held for both transaction and precautionary motives (Mendoza 2004). In principle, countries hold reserves in order to meet unexpected and temporary fluctuations in international payments. In this context, the optimal size of reserves depends on the balance between the macroeconomic adjustment costs that result if reserves are exhausted and the opportunity cost of holding reserves (Heller 1966). Thus, a country's demand for reserves will increase with its risk aversion and output volatility (Gosselin and Parent 2005).

According to Gosselin and Parent (2005) there is a relatively stable long run reserve demand function that depends on five categories of explanatory variables: economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility, and the opportunity cost. Reserve holding is expected to increase with economic size and the volume of international transactions. Thus, in view of the nature of commodity-based production and exports in Africa, both the level and growth rate of output are expected to influence reserve accumulation. Increased current and capital account vulnerability should motivate central banks to hold more reserves, while exchange rate flexibility reduces the demand for reserves. Economic theory predicts that the higher the opportunity cost of holding reserves the lower would be the demand for reserves.

We specify a simple long-run reserve demand equation as follows:

$$RR_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 CAAV_{it} + \beta_3 CUAV_{it} + \beta_4 ER_{it} + \beta_5 OC_{it} + \varepsilon_{it} \qquad (5)$$

Where RR is real reserves, CAAV is capital account vulnerability, CUAV is current account variability, ER is nominal exchange rate, and OC is the opportunity cost of holding reserves. Capital account vulnerability may be measured by the ratio of short-term debt to total debt, while current account volatility can be proxied by the trade openness/variability. The opportunity cost (OC) is measured by the difference between

the real return on reserves and the real return to domestic investments (real US treasury bill rate minus real domestic interest rate).[4] An alternative proxy for OC is the difference between (real) US Treasury bills rate and individual country real GDP growth rate (3-years moving average), an indicator of the rate of profitability of domestic investment.

3.2 The impact of reserve accumulation

The second objective of the study is to investigate the linkages between movements in foreign exchange reserves (accumulation or depletion) and economic variables of interest. The study explores the following empirical questions:

(i) **Does accumulation of reserves crowd out public investment**?
The hoarding of reserves (from whatever sources, e.g., debt relief, export boom, etc.) prevents governments from spending on public infrastructure. We investigate this question through analysis of a simple quantity constraint on public investment, which is assumed to depend on real GDP growth and domestic credit to the public sector (*PUCRED*) beside foreign exchange reserves.

The public investment equation is specified as follows:

$$PuI_{it} = \beta_0 + \beta_1 \dot{Y}_{it} + \beta_2 PUCRED_{it} + \beta_3 RR_{it} + \varepsilon_{it} \qquad\qquad (6)$$

Where $\dot{Y}$ is the growth rate of real GDP, and all other variables are the same as defined earlier. We also explore the role of ODA in alternative specifications.

(ii) **What are the linkages between reserves and private investment**?
There are two possible channels of the linkages between reserves and private investment. The first is a quantity channel, whereby the availability of reserves makes it possible to import capital goods, thus facilitating increased domestic private investment. The second is the rate of return channel, which works through the interest rate parity relationship:

$$i_t = i_t^f + E(\dot{\varepsilon}_t); E(\dot{\varepsilon}_t) = \frac{E(\Delta \varepsilon_t)}{\varepsilon_t} ; \qquad\qquad (7)$$

Where i , i^f , and E($\dot{\varepsilon}$) are the domestic interest rate, the world interest rate, and the expected appreciation/depreciation of the exchange rate, respectively. For a given world interest rate, expectations of domestic currency appreciation (due to expectations of higher reserves, among other things) encourage domestic investment because the domestic return is higher. Expectations of depreciation induce investment abroad (capital outflow). We investigate the relationship between foreign exchange reserves and private investment behavior in a model that includes accelerator variables (real GDP growth), public investment (PuI) and bank credit to the private sector (PRCRED). While growth and financial development (PRCRED) are expected to stimulate private investment, the

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[4] We used the deposit rate rather than the lending rate because of data limitations.

effect of public investment may be positive or negative depending on whether public investment crowds in or out private investment.

The private investment equation is specified as follows:

$$\text{Pr}\, I_{it} = \beta_0 + \beta_1 \dot{Y}_{it} + \beta_3 PRCED_{it} + \beta_4 PuI_{it} + \beta_5 R R_{it} + \varepsilon_{it} \qquad (8)$$

All the variables are the same as defined above.

(iii) **What is the linkage between reserve accumulation and the exchange rate**? Adequate stock of foreign exchanges allows monetary authorities to intervene in the market to protect the exchange rate (e.g., injecting foreign exchange in case of pressures towards appreciation). However, excessive inflows of reserves can cause the currency to appreciate. Moreover, high volatility of reserves can cause instability in the exchange rate. This paper examines the role of reserves in exchange rate movements using a conventional exchange rate equation with the domestic and foreign price and interest rate differentials as the two key explanatory variables besides foreign exchange reserves. A rise in the domestic interest rate relative to the foreign rate is expected to attract increased foreign capital flows, resulting in exchange rate appreciation. Of course this assumes the existence of an active financial market that is reasonably integrated into the global market. Conversely, an increase in domestic prices relative to foreign prices would lead to a shift in demand in favor of foreign goods and cause the exchange rate to depreciate.

The exchange rate equation to be estimated is the following:

$$ER_{it} = \beta_0 + \beta_1 \left(i^d - i^f \right)_{t-1} + \beta_2 (\hat{p}_d - \hat{p}_f)_{t-1} + \beta_3 RR_{it} + \varepsilon_{it} \qquad (9)$$

Where $\hat{p}_d$ is domestic inflation, P_f is foreign inflation, i^f is nominal foreign interest rate, and i^d is nominal domestic interest rate. Other determinants of the exchange rate that may be examined include capital flows (e.g. ODA), current account balance (CAB) and money supply.

(iv) **What are the linkages between reserves and inflation**?
We explore two possible channels. The first is the exchange rate expectations channel. With high reserves, agents expect the national currency to appreciate, which reduces (expected) inflation. The second is the liquidity/money market effect: the spending of reserves increases the stock of money (e.g., when government converts aid into domestic currency to spend it), which may fuel inflation. We investigate whether the data supports this prediction, i.e., whether inflation has increased in this sample of countries following the large inflows of foreign exchange.

The inflation equation is the following:

$$\hat{p}_{it} = \beta_0 + \beta_1 \hat{p}_{t-1} + \beta_2 RR_{it-1} + \varepsilon_{it} \qquad (10)$$

In alternative specification, we also explore the effect of money supply growth and the expected exchange rate.

4. Estimation and discussion of results

The empirical analysis starts with the investigation of the time series characteristics of the regression variables. The tests show that all of the macroeconomic variables used in this study are integrated of order 1, i.e. I(1), or non-stationary in logs, while the differenced variables (inflation and interest rate differentials) are I(0). Also we used (Kao and Pedroni) cointegration tests to inform the specification of the equations so as to avoid spurious regressions. The results of the panel unit root and cointegration tests are reported in tables A6 and A7 in the appendix.

The regression equations were estimated for the sample 21 African countries for the period 1979-2005. The estimation results for level, first-differenced, and two-step error correction models are presented in tables 3-7 for reserve demand, public investment, private investment, the exchange rate and inflation. These results are discussed below.

The determinants of the demand for reserves

The long-run (level) regression results show that the demand for international reserves in Africa is driven mainly by exports and GDP growth (table 3). These two variables have positive and statistically significant coefficients. The sizes of coefficients (elasticities) indicate that the real exports effect is greater than the real GDP effect, underscoring the role of commodity exports (oil and non-oil) in reserve buildup in African countries. On the other hand both the opportunity cost of holding reserves (measured by the difference between domestic and foreign interest rates) and short-term debt have negative but insignificant effects on demand for reserves.

Continued reserve buildup despite the weak return effect is another indication that reserve accumulation in Africa is not motivated by returns. Though weak, the negative coefficient on short-term debt indicates a burden rather than hedging effect, as African countries with more short-term debt are the ones that have less reserve. As stylized data analysis show, these countries are less likely to accumulate reserves due to high debt service and thus might be able to hedge against risks associated with short-term debt. Conversely, relatively rich African countries continue to buildup reserves even if they do not face notable short-term debt risks.

The results with the first-differenced equation confirm the long run results regarding the positive and strong effects of GDP and exports on reserve demand. However, short-term debt and the return or opportunity cost variable continue to have no significant impact on reserve demand in the short-run. These results are consistent with the observation that poor African countries are unlikely to buildup reserves to hedge against short-term debt risks and that reserve accumulation is rarely motivated by returns to assets. The oil dummy variable suggests that oil-exporting countries tend to have more but not

significantly higher reserves than oil-importing countries. The two-step error correction results largely confirm the results with the first-differenced specification.

Public investment

The determinants of public investment remain largely the same in the short-term and the long-term (table 4). Real public investment declines with real GDP, indicating the inability of governments to sustain high public investment. Public credit has a theoretically consistent positive impact on public investment. The finding that ODA stimulates public investment strongly supports the call for scaling up ODA and debt relief to assist African countries to increase public investment and accelerate progress toward achieving the Millennium Development Goals (MDGs). At the same time, the finding on public credit justifies expansionary fiscal and monetary policy for African governments to boost domestic investment and growth.

The results show that while there is a positive and significant long-run relationship between reserves and public investment, no such relationship exists in the short-run. The evidence suggests that short-term movements in reserves such as the buildup observed in recent years have not been used to increase public investment. This may be due to African countries' pursuit of restrictive macroeconomic policy and their excessive aversion to financial crisis. This approach may prevent African countries from reaping the full benefits from the resource boom as well as the increase in external capital inflows.

Private investment

Accumulation of reserves strongly stimulates private investment in Africa in the long run, but this effect is weak in the short-run (table 5). This finding is consistent with the fact that reserves buildup signals improvements in macroeconomic management, but private investors would only respond to this signal when it is seen as permanent. It is interesting to note that public investment compliments private investment in Africa in the long run. This result is consistent with our *a priori* expectation as most African countries suffer from poor infrastructure and weak institutional environment. Increased public investment in infrastructure is therefore a factor that stimulates private investment in these countries especially when these changes are seen as permanent.

It is also important to note that increased availability of bank credit to the private sector fosters private investment in Africa. Thus higher domestic credit stimulates both public and private investments, which are positively correlated over the long run. This suggests that although increased public borrowing can raise domestic interest, making it unprofitable for the private sector to borrow to finance investment, the credit effect dominates the interest rate or cost effect.

Regression results show a negative relationship between real GDP and private investment in the long run as well as the short-run. Indeed, plotting average GDP against average private investment for each of the sample countries shows that, with the exception a few

countries such as Sudan, private investment lags behind expansion in GDP. Again this underscores the fact that GDP growth in Africa is largely driven by developments in the primary commodity sector, with little direct effect on private investment. The results also illustrate the fact that growth in African countries has not been sustained over a long period, which undermines incentives to invest. Indeed, volatility of GDP growth implies high volatility of returns to capital, which discourages private investment.

The exchange rate

The nominal exchange rate strongly responds to changes in international reserves over both the short-run and the long-run (table 6). As theory suggests a rise in reserves causes the nominal exchange rate to immediately appreciate and, if the increase in reserves is permanent, the appreciation is also permanent. Thus, unlike the case in other developing regions, African countries do not accumulate reserves to keep exchange rates low and promote international trade and competitiveness. On the other hand, increases in the domestic price level relative to foreign prices leads to nominal exchange depreciation over both the short and long term. But the nominal exchange rate robustly appreciates as the domestic interest rate rises relative to the foreign interest rate. This finding is consistent with standard economic theory as increased domestic return on assets might attract increased private capital inflows. The current exchange rate level appears to be a good predictor of its future level, underscoring the relative stability and predictability of African nominal exchange rates.

Inflation and reserves

The paper has estimated the determinants of the domestic price level as well as inflation. The results are largely the same as regards the signs and significance of coefficients (table 7). The estimated inflation equation provides interesting and theoretically consistent results. Lagged inflation is the main determinant of current inflation. There is evidence that inflationary pressures rises as real GDP growth increases, indicating that there is a sign of overheating as a result of GDP growth. This effect is particularly important for oil-rich countries, where increased oil revenues fuel government and private consumption that creates excess demand while the economy does not have the adequate supply capacity to respond (see UNECA 2008).

Accumulation of international reserves has no significant effect on inflation, but induces higher price levels in the long run. However, changes in money supply and changes in the expected nominal exchange rate have no significant impact on current inflation. The results suggest that monetary authorities have succeeded in containing the inflationary impact of foreign exchange inflows by hoarding the reserves, thus minimizing their effects on money supply. This certainly serves the narrow objective of monetary policy, namely controlling inflation. But this "success" comes at the cost of the forgone gains from reserves in terms of domestic investment.

5. Conclusions and policy recommendations

This paper has provided quantitative evidence on the recent increase in foreign exchange reserves in African countries, which is driven primarily by the primary commodity export boom as well as development aid. African countries have accumulated these reserves in the context of a macroeconomic policy orientation that focuses on stabilization, especially inflation targeting. The trends in Africa are consistent with those in other developing regions, which also experienced substantial buildup of reserves, thus financing the current account and budget deficits in industrialized countries, especially the United States.

The study has investigated the motivations, sources, and impact of the reserves accumulation, with a focus on the impact on key macroeconomic variables, namely public and private investment, the exchange rate, and inflation. The empirical analysis shows that reserves hoarding cannot be justified by returns to assets considerations, given the low world interest rates and the high rates of returns to domestic assets in African countries (high domestic real interest rates). Therefore, reserves accumulation can carry a high opportunity cost for African countries and imply cheap financing of the deficits for reserve asset countries.

A key result of the empirical analysis is that reserves accumulation has been accompanied by appreciation of national currencies. Exchange rate appreciation undermines export competitiveness and hampers efforts aimed at diversification of exports. It can adversely affect domestic investment and employment creation and limit progress towards meeting national development goals.

The analysis shows that the increase in foreign exchange reserves has no significant impact on inflation, but a significant positive effect on the price level in the long run. This signifies that reserve accumulation may not be conducive to stabilization objectives. However, the evidence suggests that monetary authorities have been successful in containing the expansionary effects of foreign exchange inflows, notably by minimizing their impact on money supply. This strategy comes at a cost as it prevents African countries from taking advantage of exports expansion and external resource inflows to stimulate domestic investment. Indeed the results show that in the short run, increases in reserves have not been accompanied by increases in public investment.

The empirical results in this study suggest that African countries may want to reconsider their reserve management strategies within a broader economic development policy framework. While macroeconomic stabilization, especially inflation control, must remain an important objective of macroeconomic policy, there is a need to design strategies that maximize the gains from export revenues and external resource inflows by utilizing more of these resources to boost domestic investment. At the forefront of policy interventions must be strategies for encouraging allocation of these resources to stimulate diversification of exports away from primary commodities.

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Figure 1: Reserves buildup in developing countries, 1997-2005 ($ billion)
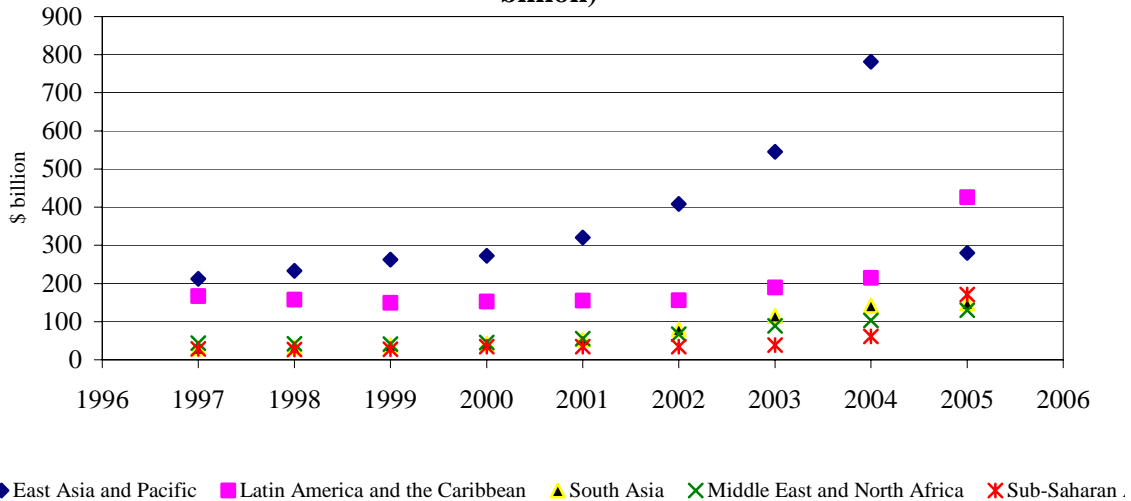
Source: Global Development Finance (GDF) 2006

Figure 2: Reserves as aratio of imports of goods and services (months)
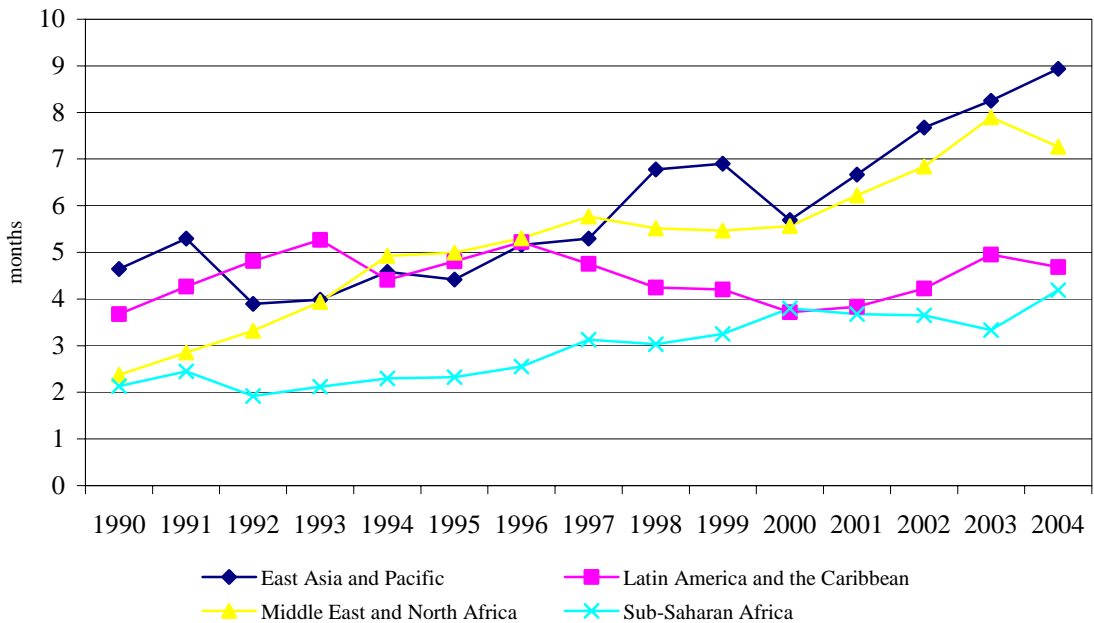
Source: GDF 2006

Figure 3: Reserves as a ratio of short-term debt, 1997-2005

Legend:
- East Asia and Pacific
- Latin America and the Caribbean
- Middle East and North Africa
- South Asia
- Sub-Saharan Africa
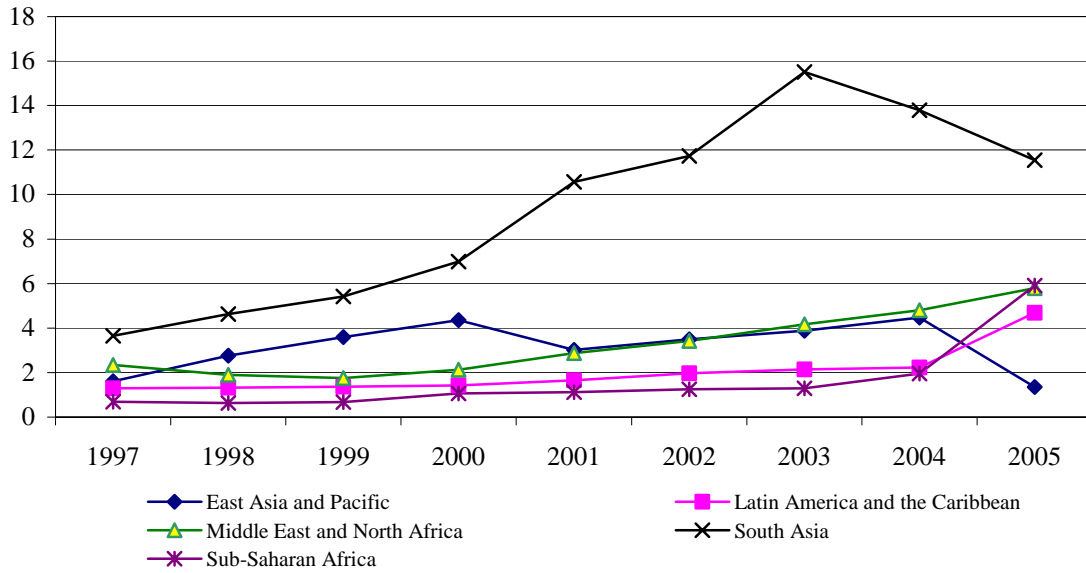
Source: GDF 2006

Figure 4: Oil and reserve accumulation in Africa (USD Billion)

Legend: Africa — Oil-rich countries — Non-oil countries
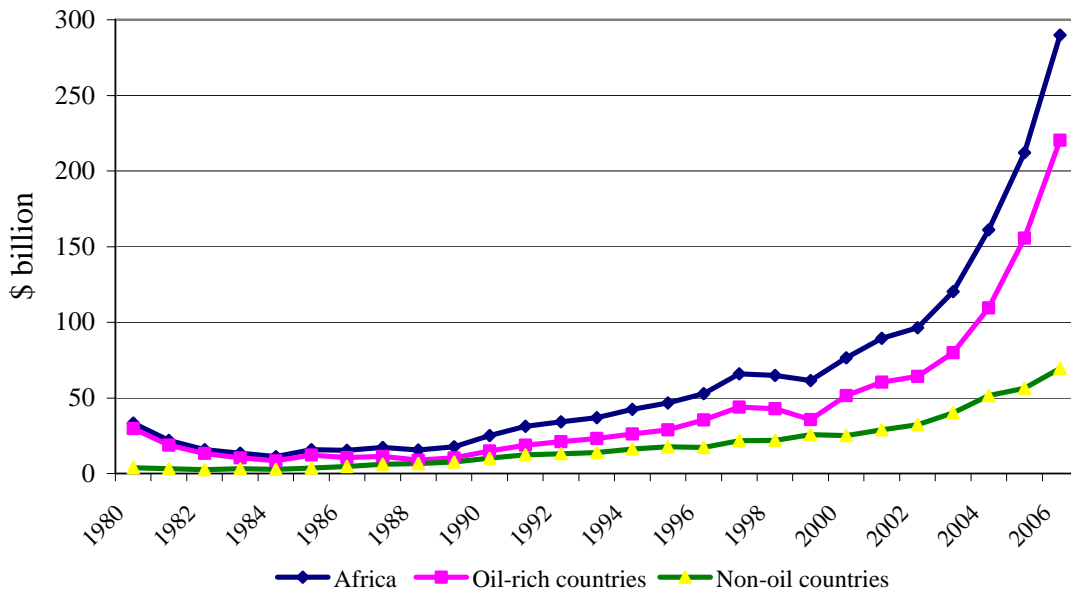
Source: International Financial Statistics (IFS) 2007 (Covers 39 countries with available data)

Figure 5: Capital flows and reserves buildup in sub-Saharan Africa, 1998-2005
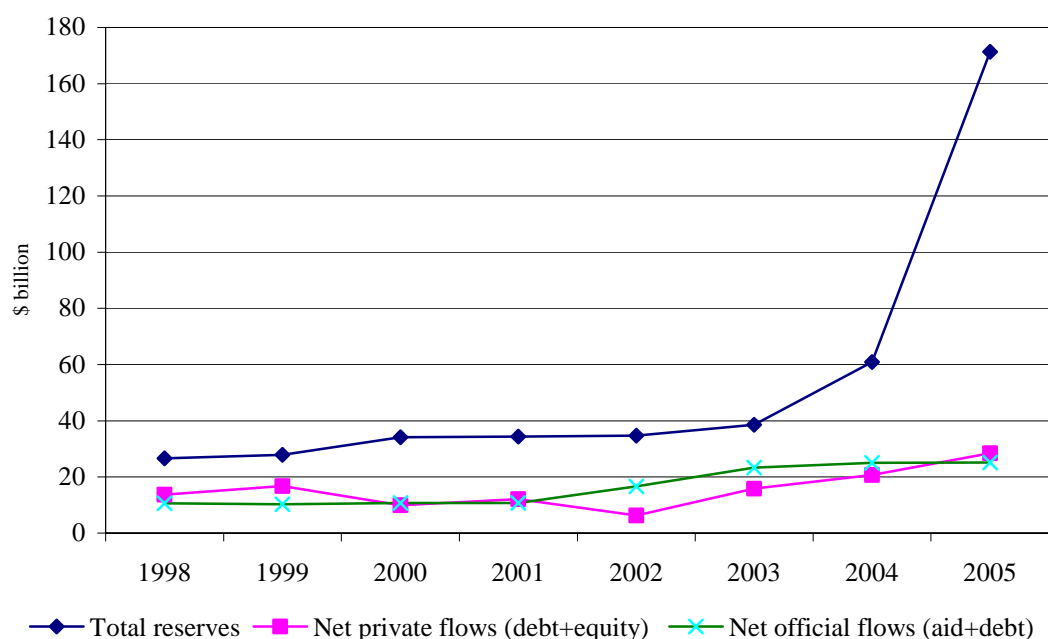
Source: IMF/IFS 2006

Table 1: Sources of reserves accumulation in Africa (US$ million)

	Current account balance			Capital and financial account balance		Change in reserves (CRES3)	ODA
	Balance on goods and services (BGAS)	*Balance on income (BOI)*	*Balance on transfers (Btransfer)**	*Capital account balance (CAA3)*	*Financial account balance (FA)*		
1990	4251.6	-12386.3	10479.9	6052.6	-13756.0	-5358.3	14617.3
1995	-8776.7	-19599.5	9903.4	2114.6	3113.5	-4468.1	9221.8
2000	3998.2	-6665.6	11303.6	1767.3	-8246.2	-1840.8	6084.9
2001	-203.3	-10759.8	12722.0	-755.2	-5265.9	-4058.9	6641.3
2002	491.4	-10807.2	12965.0	10114.9	-13350.6	-1077.9	8036.6
2003	5869.3	-7820.9	14101.9	5003.9	-18365.7	-7080.9	8170.0
2004	8661.0	-5436.6	17866.0	-27147.0	-9165.3	-23883.0	11858.4
2005	10100.9	-7651.4	20774.8	-35568.8	-2215.3	-24682.1	NA
Average 1980-89	-4063.4	-12150.7	6351.6	4218.0	1512.2	-74.1	6931.1
Average 1990-99	-4201.0	-15059.8	11131.6	1054.8	-1050.3	-3498.5	10290.7
Average 2000-04	4819.6	-8190.3	14955.6	-7764.2	-9434.8	-10437.2	6798.5

Source: IFS 2006/GDF 2006

Notes: Data are for 21 countries only; * includes remittances and other current transfers (net).

Table 2: Composition of African reserves - US$ million (all countries)

	Gold	SDRs	Reserve position in the IMF	Foreign exchange* Amount	% of total	Total reserves excl. gold
1990	2200.9	88.6	66.2	15746.4	99.0	15901.2
1995	2527.7	252.4	245.7	34790.3	98.6	35288.5
2000	2238.9	530.0	369.9	46468.7	98.1	47368.7
2001	2176.5	531.0	212.0	50684.6	98.6	51427.6
2002	2611.5	620.2	231.8	51653.5	98.4	52505.5
2003	2466.2	807.8	274.6	58504.1	98.2	59586.5
2004	2676.7	800.5	272.1	82396.7	98.7	83469.4
2005	3276.7	613.6	226.0	107311.8	99.2	108151.5
Average 1980-89	3376.5	174.9	217.2	7202.4	94.8	7594.5
Average 1990-99	2341.6	283.5	225.5	32733.6	98.5	33242.5
Average 2000-05	2574.4	650.5	264.4	66169.9	98.6	67084.9

Source: IFS (2006) and GDF 2006.
Notes: * Include currency plus deposits with monetary authorities and banks plus securities (US/foreign government securities, equity, bonds and notes, money markets, derivatives).

Econometric results:

Table 3. Determinants of demand for reserves

Explanatory Variables	Fixed effects +Cross-section Weights		Two-step ECM	
	In levels (1)	In 1st differences (2)	(3a)	(3b)
GDP	0.482 (18.41)	0.230 (1.43)	0.381 (3.00)	0.283 (1.90)
Exports	0.525 (11.30)	0.645 (5.35)	0.676 (6.97)	0.623 (5.73)
S.T debt	-0.012 (-0.29)	-0.014 (-0.463)	0.007 (0.261)	-0.020 (-0.711)
Opportunity cost[a]		-0.0021 (-0.819)		-0.003 (-1.15)
Export variability[b]		3.60E-06 (0.519)		
Residual (lagged)			-0.246 (-8.14)	-0.266 (-7.86)
Adjusted R^2	0.94	0.08	0.20	0.21
DW	0.60	2.03	1.84	1.80
Observations	491 (1979-2004)	386 (1981-2004)	468 (1980-2004)	386 (1981-2004)

 Notes: The dependent variable is log of real reserves in level (colum1) and in 1st difference (columns 2 and 3); a: opportunity cost is the real US treasury bill rate minus the real domestic deposit rate (this variable was lagged by one year lag in the case of equations 2 and 3); b: Export variability is measured by a moving standard deviation of exports; The figures in parentheses are t- statistics; All variables are in real national currency; Coefficient on the constant not reported for reason of space.

Table 4. Impact of reserves on public investment

Explanatory variables	Fixed effects plus cross section weights				Two-step ECM	
	In levels (1a)	In levels (1b)	1st differences (2a)	1st differences (2b)	(3a)	(3b)
Reserves	0.409 (13.08)		0.027 (1.37)		0.026 (1.44)	
GDP*	-0.677 (22.15)	-0.71 (-27.55)	-0.038 (-0.42)	-0.072 (-4.33)	-0.108 (-1.37)	-0.121 (-1.54)
Public credit	0.460 (14.71)	0.425 (15.69)	0.086 (2.22)	0.087 (2.29)	0.08 (2.28)	0.083 (2.41)
ODA		0.329 (15.65)		0.087 (2.72)		0.086 (2.84)
Oil rich dummy	1.437 (11.71)	1.53 (14.48)				
Residual (lagged)					-0.22 (-8.30)	-0.200 (-7.49)
Adjusted R^2	0.72	0.80	0.01	0.02	0.16	0.15
DW	0.25	1.83	1.86	1.83	1.71	1.88
Observations	420	420	394	394	394	394

Notes: The dependent variable is the log of real public investment.

Table 5. Impact of reserves on private investment

Explanatory variables	Fixed effects + cross-section weights		Two-step ECM
	In levels	In 1st difference	
Reserves	0.081 (7.08)	0.014 (1.079)	0.015 (1.23)
GDP_{t-1}	-0.409 (-15.65)	-0.154 (2.40)	-0.195 (-3.12)
Private credit	0.231 (7.09)	0.210 (2.90)	0.161 (2.27)
Public investment	0.247 (8.83)	-0.039 (1.244)	-0.011 (-0.36)
Residual (logged)			-0.313 (-8.85)
Adjusted R^2	0.96	0.024	0.192
Durbin Watson	0.93	2.27	2.09
Observation	394	374	374

Notes: The dependent variable is the log of real private investment.

Table 6. Impact of reserves on the nominal exchange rate

Explanatory variables	Fixed effects Fixed effects			Two-step ECM	
	In levels (1)	In 1st differences * (2a)	In 1st differences* (2a)	(3a)	(3b)
Log Reserves $_{t-1}$	-0.023 (-3.83)	-0.034 (-3.87)	-0.027 (-3.08)	-0.041 (-4.97))	-0.038 (-4.61)
Log exchange rate $_{t-1}$	0.749 (25.01)	0.062 (1.33)	0.023 (0.46)	0.735 (7.66)	0.711 (8.05)
Log CPI	0.209 (7.21)	0.726 (6.09)		0.607 (5.32)	
Log deposit rate	0.035 (1.66)	0.012 (0.37)		-0.009 (-0.28)	
Inflation differential $_{t-1}$ [a]			0.006 (5.56)		0.005 (5.16)
Interest rate differential [b]			-0.009 (-4.48)		-0.007 (-4.03)
Residual $_{t-1}$				-0.830 (--7.84)	-0.830 (-8.02)
Adjusted R^2	0.99	0.16	0.19	0.27	0.29
Durbin Watson	1.1.62	1.92	1.82	1.88	1.85
Observations	458	430	415	430	407

Notes: a: The difference between domestic and foreign (US) consumer inflation rates; b: The difference between domestic and foreign (US treasury bill) real interest rates; the dependent variable is the nominal exchange rate defined as the price of the dollar in national currency; Figures in () are t-statistics; * 1st difference does not apply to inflation and interest rate differentials.

Table 7. Impact of reserves on domestic prices (level and inflation)

Explanatory variables	With reserves			With money supply and exchange rate		
	In Level	1st differences	2-Step ECM	In Level	1st differences	2-Step ECM
Log reserves	-0.078 (-1.46)	0.012 (10.89)	0.013 (4.18)			
Log real GDP	0.025 (3.04)	0.064 (4.05)	0.07 (4.81)			
Log CPI $_{t-1}$	0.938 (82.69)	0396 (9.49)	0.951 (10.77)	0.951 (101.5)	0.363 (8.99)	0.844 (9.07)
Log M2				-0.003 (-1.46)	0.017 (0.99)	-0.001 (-0.05)
Expected exchange rate*				0.020 (2.14)	0.143 (6.55)	0.146 (6.25)
Residual $_{t-1}$			-0.677 (-7.01)			-0.603 (-6.04)
Adjusted R-Squared	0.99	0.51	0.56	0.99	0.54	0.54
Durbin Watson	1.33	2.06	2.02	1.34	2.00	1.80
Observations	494	471	471	511	487	456

Notes: Dependent variable is the domestic consumer price inflation rate; * computed as a 3-year moving average; Figures in () are t-statistics.

Appendix tables

Table A1: Reserves and selected economic indicators of sample countries, 1980-2005 (average)

COUNTRY	RESERVES \$ million	GDP GROWTH	INFLATION	PRIVATE INVESTMENT/GDP	PUBLIC INVESTMENT/GDP	PRIVATE CREDIT/ TOTAL CRDIT	PUBLIC CREDIT/ TOTAL CREDIT	ODA \$ Million	RATIO M2/GDP
BOTSWANA	3693.2	7.8	10.2	20.4	8.4	91.8	8.2	114.0	23.8
CONGOR	196.6	4.3	4.9	16.1	8.0	29.1	70.9	149.1	16.4
COTE D'IVOIRE	430.5	0.8	5.7	8.0	5.7	85.3	14.7	557.2	26.0
EGYPT	8958.8	5.0	12.1	12.2	11.4	50.1	49.9	2330.5	77.9
ETHIOPIA	423.2	3.2	5.7	8.6	7.1	91.1	8.9	906.5	37.0
GABON	192.2	2.2	4.3	22.9	6.3	0.0	100.0	89.1	17.3
GHANA	524.6	3.4	34.8	8.1	9.4	0.0	100.0	594.8	17.3
KENYA	625.3	3.1	13.3	8.2	7.3	75.2	24.8	691.5	31.3
LESOTHO	265.6	4.0	12.5	34.2	17.3	56.6	43.4	114.5	34.1
MADAGASCAR	194.7	1.3	16.3	5.8	6.9	86.7	13.3	421.6	18.0
MAURITIUS	648.6	5.4	8.5	18.9	5.1	71.5	28.5	46.3	64.2
MOROCCO	4161.0	3.5	5.1	18.8	8.2	66.6	33.4	741.9	58.4
NIGER	149.5	1.4	3.5	3.5	8.3	45.5	54.5	343.5	14.0
NIGERIA	5610.6	2.6	23.3	9.6	9.0	72.7	27.3	198.8	22.3
RWANDA	145.4	3.2	6.3	8.5	9.0	79.7	20.3	349.3	14.7
SENEGAL	266.4	3.1	4.8	9.4	5.2	91.0	9.0	599.0	25.0
SEYCHELLES	27.8	2.6	3.2	17.2	9.9	28.3	71.7	21.6	56.7
SOUTH AFRICA	3190.4	2.1	10.9	10.2	5.9	63.1	36.9	402.7	51.2
SUDAN	188.0	4.4	48.2	11.4	3.2	88.1	11.9	700.8	17.2
SWAZILAND	229.1	4.7	11.8	14.9	8.5	92.9	7.1	46.5	26.4
TUNISIA	1468.7	4.4	5.1	15.4	13.1	50.5	49.5	279.1	46.4

Table A2: Sources of reserves accumulation in Africa US$ million (oil-rich countries)

	Current account balance			Capital and financial account balance		Change in reserves (CRES3)	ODA
	Balance on goods and services (BGAS)	*Balance on income (BOI)*	*Balance on transfers (Btransfer)**	*Capital account balance (CAA3)*	*Financial account balance (FA)*		
1990	3357.4	-5428.0	6324.8	7664.7	-15248.6	-3329.7	7251.9
1995	-4517.7	-9880.5	5663.7	2142.7	-894.6	-2968.7	2815.11
2000	5309.6	-51.1	6779.9	-1499.4	-8176.9	-2947.5	2006.4
2001	-353.7	-5370.6	6490.3	1317.5	-2547.9	-110.7	2088.68
2002	-870.3	-6739.3	6994.7	11197.3	-9236.8	2215.9	2297.67
2003	6840.5	274.6	6460.0	7102.0	-14975.6	-1139.1	2279.43
2004	18823.1	11721.9	9217.4	-17652.6	-15928.9	-12642.2	3394.87
2005	23063.0	12153.6	11738.3	-28410.9	-14784.8	-19528.8	NA
Average 1980-89	-4338.0	-7358.4	4110.6	3280.2	215.7	248.2	2869.578
Average 1990-99	-2923.1	-8226.6	6879.5	2897.4	-3699.8	-1813.8	4050.417
Average 2000-04	8802.0	1998.2	7946.8	-4657.7	-10941.8	-5692.1	2011.175

Source: IFS 2006/GDF 2006

Notes: Data are for 21 countries only; * includes remittances and other current transfers (net).

Table A3: Composition of African reserves - US$ million (oil-rich countries)

	Gold	SDRs	Reserve position in the IMF	Foreign exchange*		Total reserves excl. gold
				Amount	% of total	
1990	656.9	6.2	0.9	7626.7	99.9	7633.8
1995	718.9	111.0	80.9	19408.7	99.0	19600.7
2000	520.9	52.4	183.8	25153.2	99.1	25389.4
2001	497.8	37.4	26.4	25436.3	99.7	25500.2
2002	582.7	97.6	28.6	23158.0	99.5	23284.3
2003	644.8	192.4	31.3	24199.7	99.1	24423.3
2004	731.3	188.4	32.8	36844.4	99.4	37065.6
2005	794.7	106.3	30.2	56457.9	99.8	56594.4
Average 1980-89	670.5	78.5	123.0	3984.3	95.2	4185.8
Average 1990-99	638.4	89.1	73.4	18312.3	99.1	18474.8
Average 2000-05	628.7	112.4	55.5	31874.9	99.5	32042.9

Source: IFS (2006) and GDF 2006.

Notes: * Include currency plus deposits with monetary authorities and banks plus securities (US/foreign government securities, equity, bonds and notes, money markets, derivatives).

Table A4: Sources of reserves accumulation in Africa – US$ million (non-oil economies)

	Current account balance			Capital and financial account balance		Change in reserves (CRES3)	ODA
	Balance on goods and services (BGAS)	*Balance on income (BOI)*	*Balance on transfers (Btransfer)**	*Capital account balance (CAA3)*	*Financial account balance (FA)*		
1990	894.2	-6958.3	4155.1	-1612.2	1492.5	-2028.6	7365.4
1995	-4258.9	-9719.0	4239.7	-28.1	4008.0	-1499.4	6406.7
2000	-1311.4	-6614.5	4523.7	3266.7	-69.2	1106.7	4078.5
2001	150.4	-5389.3	6231.7	-2072.7	-2718.0	-3948.3	4552.6
2002	1361.7	-4067.9	5970.3	-1082.4	-4113.8	-3293.8	5739.0
2003	-971.2	-8095.6	7642.0	-2098.1	-3390.1	-5941.8	5890.6
2004	-10162.1	-17158.5	8648.7	-9494.4	6763.6	-11240.7	8463.5
2005	-12962.2	-19805.0	9036.4	-7157.9	12569.4	-5153.3	NA
Average 1980-89	274.6	-4792.3	2241.0	937.8	1296.5	-322.3	4061.5
Average 1990-99	-1277.9	-6833.1	4252.2	-1842.6	2649.4	-1684.7	6240.3
Average 2000-04	-3982.5	-10188.5	7008.8	-3106.5	1507.0	-4745.2	4787.4

Source: IFS 2006/GDF 2006

Notes: Data are for 21 countries only; * includes remittances and other current transfers (net).

Table A5: Composition of African reserves – US$ million (non-oil economies)

	Gold	SDRs	Reserve position in the IMF	Foreign exchange*		Total reserves excl. gold
				Amount	% of total	
1990	1544.0	82.4	65.3	8119.7	98.2	8267.4
1995	1808.8	141.4	164.8	15381.6	98.0	15687.8
2000	1718.0	477.6	186.1	21315.5	97.0	21979.2
2001	1678.7	493.7	185.5	25248.3	97.4	25927.5
2002	2028.9	522.5	203.2	28495.5	97.5	29221.2
2003	1821.4	615.4	243.3	34304.4	97.6	35163.1
2004	1945.4	612.1	239.4	45552.3	98.2	46403.8
2005	2482.1	507.4	195.8	50853.9	98.6	51557.1
Average 1980-89	2706.0	96.4	94.2	3218.1	94.4	3408.7
Average 1990-99	1703.2	194.3	152.1	14421.2	97.7	14767.7
Average 2000-05	1945.7	538.1	208.9	34295.0	97.9	35042.0

Source: IFS (2006) and GDF 2006.

Notes: * Include currency plus deposits with monetary authorities and banks plus securities (US/foreign government securities, equity, bonds and notes, money markets, derivatives).

Table A6. Unit root tests for regression variables (in log form in million of real values of domestic currency except for differentials)

Variable	Im, Pesaran and Shin W-Stat[a]	Probability	Order of integration
Reserves	0.741	0.771	I(1)
GDP	0.036	0.514	I (1)
Export	-0.503	0.31	I (1)
ST debt	0.854	0.80	I (1)
Public Investment	0.053	0.52	I(1)
Private investment	-1.57	0.06[b]	I (1)
Public credit	1.44	0.925	I(1)
Private credit	0.167	0.566	I(1)
ODA	-0.564	0.29	I(1)
Nominal exchange rate	-1.21	0.114	I(1)
Money supply (M2)	2.37	0.99	I(1)
Nominal domestic deposit rate	-0.99	0.16	I(1)
Domestic CPI	11.26	1.00	I(1)
Foreign interest rate (US treasury bill rate) [c]	-3.07	0.001	I(1/0)
Foreign (US) CPI	10.2	1.00	I(1)
Domestic inflation (CPI)	-7.03	0.00	I(0)
Foreign (US) inflation (CPI)	-17.79	0.00	I(0)
Export variability[d]	-3.42	0.00	I(0)
Inflation differential	-6.33	0.00	I(0)
Interest rate differential[e]	-4.66	0.00	I(0)

Notes: [a] Assumes individual unit root process; [b] probability for ADF test is 0.11 with an asymptotic chi-square of 54; [c] according to the Phillips-Perron (PP), this variables is strongly I(1); [d] measured as a 3-year moving standard deviation of export value; [e] real domestic deposit rate minus the real US treasury bill rate.

Table A7. Panel cointegration tests 1979-2005 (test statistic and probability)

Equation	Group of variables	Assuming common AR coefficient:	Assuming individual AR coefficient:
Reserve demand[a]	Reserves, GDP, Exports, ST debt, domestic deposit rate, and foreign interest rate.	5.81 (0.00) Integrated	8.32 (0.00) Integrated
	Reserves, GDP, Exports, ST debt	0.40 (0.36) Not integrated	3.40 (0.00) Integrated
Public investment[a]	Reserves, public investment, GDP, and public credit	2.68 (0.01) Integrated	4.99 (0.00) Integrated
	Public investment, GDP, public credit and ODA	2.82 (0.00) Integrated	4.74 (0.00) Integrated
Private investment[a]	Reserves, private investment, GDP, Private credit, and Public Investment	2.94 (0.01) Integrated	4.88 (0.00) Integrated
Nominal exchange rate[b]	Reserves, exchange rate, inflation differential, and interest rate differential	4.22 (0.00) Integrated	6.64 (0.00) Integrated
Inflation[c]	Inflation, GDP growth, reserves, expected exchange rate and money supply	2.87 (0.01) Integrated	3.97 (0.00) Integrated

Notes: [a] variables are in log-form; [b] reserves and nominal exchange rate are in first difference of the log-form; [c] reserves and money supply are in first difference of the log-form.